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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04Q 11/00

A1

(11) International Publication Number: WO 95/34182

(43) International Publication Date: 14 December 1995 (14.12.95)

(21) International Application Number: PCT/GB95/01298

(22) International Filing Date: 6 June 1995 (06.06.95)

(30) Priority Data:
94304139.2 8 June 1994 (08.06.94) EP
(34) Countries for which the regional or international application was filed: AT et al.

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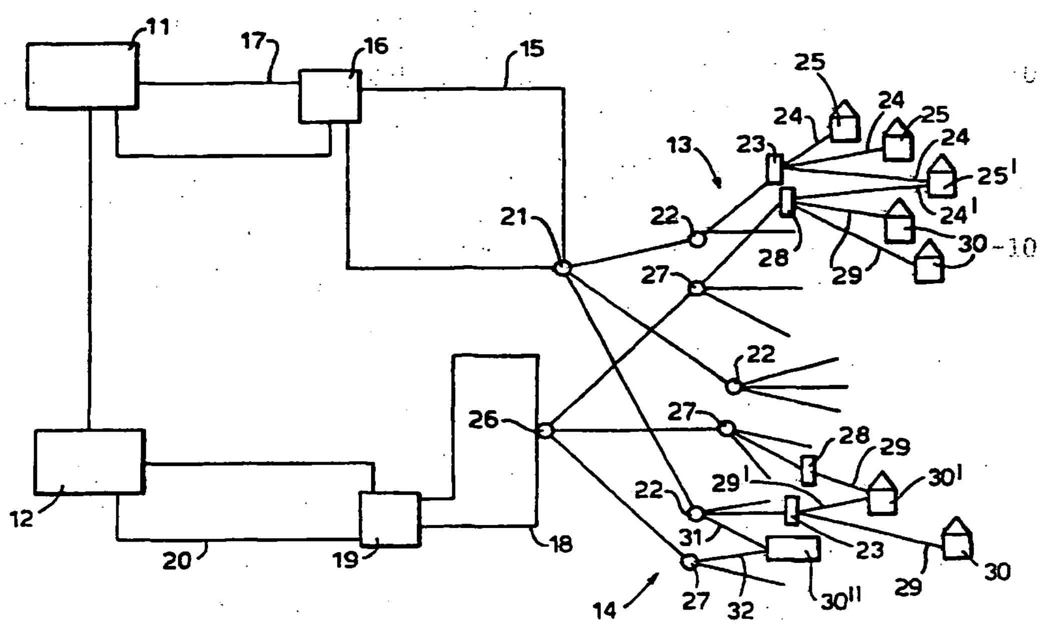
(81) Designated States: AU, CA, CN, JP, KR, NZ, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: ACCESS NETWORK



(57) Abstract

A telecommunications access network comprises a plurality of customer terminals (25, 30) and a plurality of network nodes (23, 28). Each network node (23, 28) is connected to a plurality of the customer terminals (25, 30) by respective local access lines (24, 29), whereby each customer terminal is connectible to a switch (11, 12) of a telecommunications core network via one of the network nodes. At least one of the customer terminals (25', 30') is connected to two of the network nodes (23, 28) by respective local access lines (24, 24' or 29, 29').

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ACCESS NETWORK

This invention relates to a telecommunications access network, and in particular to an optical fibre telecommunications access network.

In the United Kingdom, the telecommunications network includes a trunk network which is substantially constituted by optical fibre, and a local access network which is substantially completely constituted by copper pairs. Flexibility in the copper access network is provided at two points en route to the customer; firstly, at street-side cabinets serving up to 600 lines; and secondly, at distribution points (DPs) serving around 10-15 lines. Eventually, it is expected that the entire network, including the access network, will be constituted by fibre.

The ultimate goal is a fixed, resilient, transparent telecommunications infrastructure for the optical access network, with capacity for all foreseeable service requirements. One way of achieving this would be to create a fully-managed fibre network in the form of a thin, widespread overlay for the whole access topography, as this would exploit the existing valuable access network infrastructure. Such a network could be equipped as needs arise, and thereby could result in capital expenditure savings, since the major part of the investment will be the provision of terminal equipment on a 'just in time' basis. It should also enable the rapid provision of extra lines to new or existing customers, and flexible provision or reconfiguration of telephony services.

In order to be future proof, the network should be single mode optical fibre, with no bandwidth limiting active electronics within the infrastructure. Passive optical networks (PONs) offer total transparency and freedom for upgrade.

The most common optical network is the simplex single star, with point-to-point fibre for each transmit and receive path, from the exchange head end (HE) to the customer network terminating equipment (NTE). This network design involves high fibre count cables, and unique electro-optic provision at HE and NTE for each customer. The resulting inherent cost can only be justified for large business users, who generally also require the security of diverse routing, which increases the cost still further.

The advent of optical splitters (power dividers) allows the power transmitted from a single transmitter to be distributed amongst several customers,

thereby reducing and sharing the capital investment. In 1987, BT demonstrated this technology in a system for telephony on a passive optical network (TPON), with a 128-way split and using time division multiplex (TDM) running at 20Mb/s. This combination enabled basic rate integrated service digital network (ISDN) to be provided to all customers. In practice, the competitive cost constraint of the existing copper network precludes domestic customers from having just telephony over fibre, due to the high capital cost of equipment. This may change in the future. In the meantime, telephony for small business users (for example those having more than 5 lines) can probably break this barrier.

The wider range of services and higher capacity required by business customers makes a 32-way split more attractive for a 20Mb/s system, and this has been demonstrated by BT's local loop optical field trial (LLOFT) at Bishop's Stortford.

In summary, the use of splitter-based PON architecture will reduce the cost of fibre deployment in the access network. When compared with point-to-point fibre, savings will result from:

(i) reducing the number of fibres at the exchange and in the network;

(ii) reducing the amount of terminal equipment at the exchange;

(iii) sharing the cost of equipment amongst a number of customers;

(iv) providing a thin, widespread, low cost, fibre infrastructure; and

(v) providing a high degree of flexibility, and allowing 'just in-time' equipment and service provision.

Additionally, PON architecture can be tailored to suit the existing infrastructure resources (duct and other civil works).

Total network transparency will retain the option for future services to be provided on different wavelengths to the telecommunications, which for TPON is in the 1300nm window. By transmitting at other wavelengths, other services, such as broadband access for cable television and high definition television, or business services, such as high bit rate data, video telephony or video conferencing, can be provided. The huge bandwidth potential of fibre promises virtually unlimited capacity for the transparent network. Eventually, it may be possible to transmit hundreds of wavelengths simultaneously, as the development of technology in

optical components, such as narrow band lasers, wavelength division multiplexers (WDMs), optical filters, fibre amplifiers and tunable devices, moves forward.

For this potential to remain available, and for the access network to be used to provide many and varied services, then it must be designed and engineered to provide very high levels of security and resilience. Even for simple POTS (plain old telephony service), advance warning and live maintenance are essential to limit disruption.

A particularly important aspect of resilience is the reliability of the network, and this is particularly the case for business customers. Thus, even if a business customer has several lines, these will tend to come from the same DP, so that a failure between that DP and the up-stream cabinet, or a failure between that cabinet and the exchange, or even a failure at the exchange itself will result in loss of service to that customer.

The present invention provides a telecommunications access network comprising a plurality of customer terminals and a plurality of network nodes, each network node being connected to a plurality of the customer terminals by respective local access lines, whereby each customer terminal is connectable to a switch of a telecommunications core network via one of the network nodes, wherein at least one of the customer terminals is connected to two of the network nodes by respective local access lines, whereby said at least one customer terminal is connectable to the core network via either of said respective local access lines without duplication of any other part of the access network.

Thus, if one of the local access lines (or one of the associated network nodes) of said at least one customer terminal fails, that customer can still receive service via its other local access line, thereby providing that customer with resilience.

In a preferred embodiment, the network nodes are configured at first and second levels, each first level network node being connected to a plurality of the second level network nodes by respective line means. Advantageously, said at least one customer terminal is connected to two second level network nodes. Alternatively, said at least one customer terminal is connected to two first level network nodes. Thus, customers can be provided with resilience at either the DP (second level of network nodes) level, or at the cabinet (first level of network

nodes) level. In either case, resilience is provided at all network node levels downstream of the core network switch.

The network may further comprise at least one switch, each network node being connected to a respective switch by respective line means. Preferably, there are first and second switches, each switch being associated with a number of the plurality of network nodes, and wherein the two nodes to which said at least one customer terminal are connected are associated respectively with the first and second switches. Conveniently, the network is configured such that the second level nodes of the two switches alternate. In this way, further resilience is provided in that customers provided with resilience can still receive service even if one of the switches fails.

Advantageously, the local access lines and the line means are constituted by optical fibres. In this case, each switch (local exchange) may be associated with a respective PON, each PON having a first level of split constituted by the first level nodes, and a second level of split constituted by the second level nodes. Preferably, each PON has a primary split which feeds the nodes of the first level, and each primary split is provided on a fibre ring associated with the respective switch. Conveniently, each fibre ring is connected to its respective switch via a respective concentrator and a further fibre ring.

The invention will now be described in greater detail, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is a schematic representation of a telecommunications network which illustrates the principle of the invention;

Figure 2 is a schematic representation of a first form of telecommunications network embodying the invention; and

Figure 3 is a schematic representation of a second form of telecommunications network embodying the invention.

Referring to the drawings, Fig 1 is a schematic representation of a telecommunications access network having first and second fibre rings 1 and 2, each of which is centred on a local exchange (not shown). The ring 1 is provided with a plurality of nodes 3, each of which is connected to a plurality of customer premises 4 by respective optical fibres 5. Similarly, the ring 2 is provided with a plurality of nodes 6, each of which is connected to a plurality of customer

premises 7 by respective optical fibres 8. Each of the nodes 3 and 6 is constituted by a passive optical splitter, so that these nodes can be considered as DPs.

In order to provide resilience, some of the customer premises of the ring 1 (identified by the reference numerals 4') are connected to nearby nodes 6 of the ring 2 by respective optical fibres 5'. Similarly, some of the customer premises of the ring 2 (identified by the reference numerals 7') are connected to nearby nodes 3 of the ring 1 by respective optical fibres 8'. The optical fibres 5 and 8 are termed "main" fibres, and the optical fibres 5' and 8' are termed "standby" fibres. The customer premises 4' and 7' are, therefore, each connected to both rings 1 and 2, thereby ensuring that those premises receive service if their main fibres 5 and 8 fail, or if either of the rings 1 and 2 fails, or if either of the associated nodes 3 and 6 fails. If further resilience is required, the two rings 1 and 2 would be centred on different local exchanges, thereby protecting customers opting for resilience against exchange failure as well as against fibre failure.

Figure 2 shows a practical realisation of the invention which embodies the principle of interleaved PONs. The access network of Figure 2 includes two adjacent digital local exchanges (DLEs) 11 and 12 associated respectively with PONs 13 and 14. The PON 13 is connected to the DLE 11 via a fibre ring 15, a concentrator 16, and a synchronous digital hierarchy (SDH) fibre ring 17. Similarly, the PON 14 is connected to the DLE 12 via a fibre ring 18, a concentrator 19, and an SDH ring 20.

The PON 13 has three levels of split, including a first splitter 21 associated with the ring 15, and having a 2x4-way split. The second level of split is constituted by four splitters 22, each having a 4-way split. The third level of split is constituted by sixteen splitters 23, each having a 16-way split. The splitters 23 can be considered as DPs. Respective optical fibres 24 lead from each of the splitters 23 to associated customer premises 25. For reasons of clarity, not all the splitters 22, 23 and 24 and the associated fibres and customer premises are shown in Figure 2.

Similarly, the PON 14 has three levels of split, including a first splitter 26 associated with the ring 18 and having a 2x4-way split. The second level of split is constituted by four splitters 27, each having a 16-way split. The third level of split is constituted by sixteen splitters 28, each having a 16-way split. The

splitters 28 can be considered as DPs. Respective optical fibres 29 lead from each of the splitters 28 to associated customer premises 30. For reasons of clarity, not all the splitters 26, 27 and 28 and the associated fibres and customer premises are shown in Figure 2.

In order to provide resilience, some of the customer premises of the ring 15 (identified by the reference numerals 25') are connected to nearby splitters 28 of the ring 18 by respective optical fibres 24'. Similarly, some of the customer premises of the ring 18 (identified by the reference numerals 30') are connected to nearby splitters of the ring 15 by respective optical fibres 29'. The customer premises 25' and 30' are, therefore, each connected to both the rings 15 and 18, thereby ensuring that those premises receive service if their main fibres 24 and 29 fail, or if any of the rings 15, 17, 18 and 20 fails, or if any associated interconnecting node (splitter) 21, 22, 23, 26, 27 or 28 fails. As the rings 15 and 18 are centred on different DLEs 11 and 12, the customers opting for resilience are also protected against exchange failure as well as against fibre or node failure.

The embodiment of Figure 2 also shows a further form of resilience, in that a customer premises 30" (which may be, for example, the premises of a large business customer) is connected directly to adjacent splitters 22 and 27 of the two PONs 13 and 14 by respective fibres 31 and 32.

Figure 3 shows a second form of access network embodying the principle of interleaved PONs. The network of Figure 3 is very similar to that of Figure 2, and so like reference numerals are used for similar parts, and only the modifications will be described in detail. The main modification shown in Figure 3 is that each of the rings 15 and 18 is associated with both the concentrators 16 and 19, so that each of the PONs 13 and 14 is connected to each of the DLEs 11 and 12. This gives additional resilience to customers not connected to splitters 23 and 28 of the two rings 15 and 18. This network has the further advantage of providing additional resilience to customers connected to splitters 23 and 28 of the two rings 15 and 18 in that protection is provided against two failures in the network, as alternative routes round faults are available.

The interleaved PONs of the networks of Figures 2 and 3 ensure that the DPs (that is to say the splitters 23 and 28) are fed alternately to the DLEs 11 and 12. Customers who require a highly resilient service could pick up connections

from both the DLEs 11 and 12, thereby providing such customers with separate routes to the two DLEs. Consequently, there is no duplication of any hardware, apart from the final drop from the DPs to the customers. In the event of any DLE, concentrator or link failure, another connection route is always available.

It should be noted that, in each of the embodiments described above, only those customers who require resilience would be supplied with both main and standby fibres. Moreover, in principle, there is no distinction between main and standby fibres, so that customers opting for resilience could choose to operate using a main and standby approach, or could split their traffic between the two connections.

It should be apparent that modifications could be made to the networks described above. In particular, the principle of the invention could be incorporated into local access network arrangements utilising copper pairs as the local access lines. In this case, customers requiring resilience would be connected to the DPs of two local access networks centred on different local exchanges by separate copper pairs. It would also be possible to use the principle of the invention in local access networks having radio transmitters providing the final drop to customers. In this case, customers requiring resilience would be provided with two narrow angle transmitters, each of which would be directed towards respective nearby DPs of two local access networks centred on different local exchanges.

CLAIMS

1. A telecommunications access network comprising a plurality of customer terminals and a plurality of network nodes, each network node being connected to a plurality of the customer terminals by respective local access lines, whereby each customer terminal is connectable to a switch of a telecommunications core network via one of the network nodes, wherein at least one of the customer terminals is connected to two of the network nodes by respective local access lines, whereby said at least one customer terminal is connectable to the core network via either of said respective local access lines without duplication of any other part of the access network.

2. A network as claimed in claim 1, wherein the network nodes are configured at first and second levels, each first level network node being connected to a plurality of the second level network nodes by respective line means.

3. A network as claimed in claim 2, wherein said at least one customer terminal is connected to two second level network nodes.

4. A network as claimed in 2, wherein said at least one customer terminal is connected to two first level network nodes.

5. A network as claimed in any one of claims 1 to 4, further comprising at least one switch, each network node being connected to a respective switch by respective line means.

6. A network as claimed in claim 5, wherein there are first and second switches, each switch being associated with a number of the plurality of network nodes, and wherein the two nodes to which said at least one customer terminal are connected are associated respectively with the first and second switches.

7. A network as claimed in claim 6 when appendant to claim 3, wherein the network is configured such that the second level nodes of the two switches alternate.

8. A network as claimed in any one of claims of 1 to 7, wherein the local access lines and the line means are constituted by optical fibres.

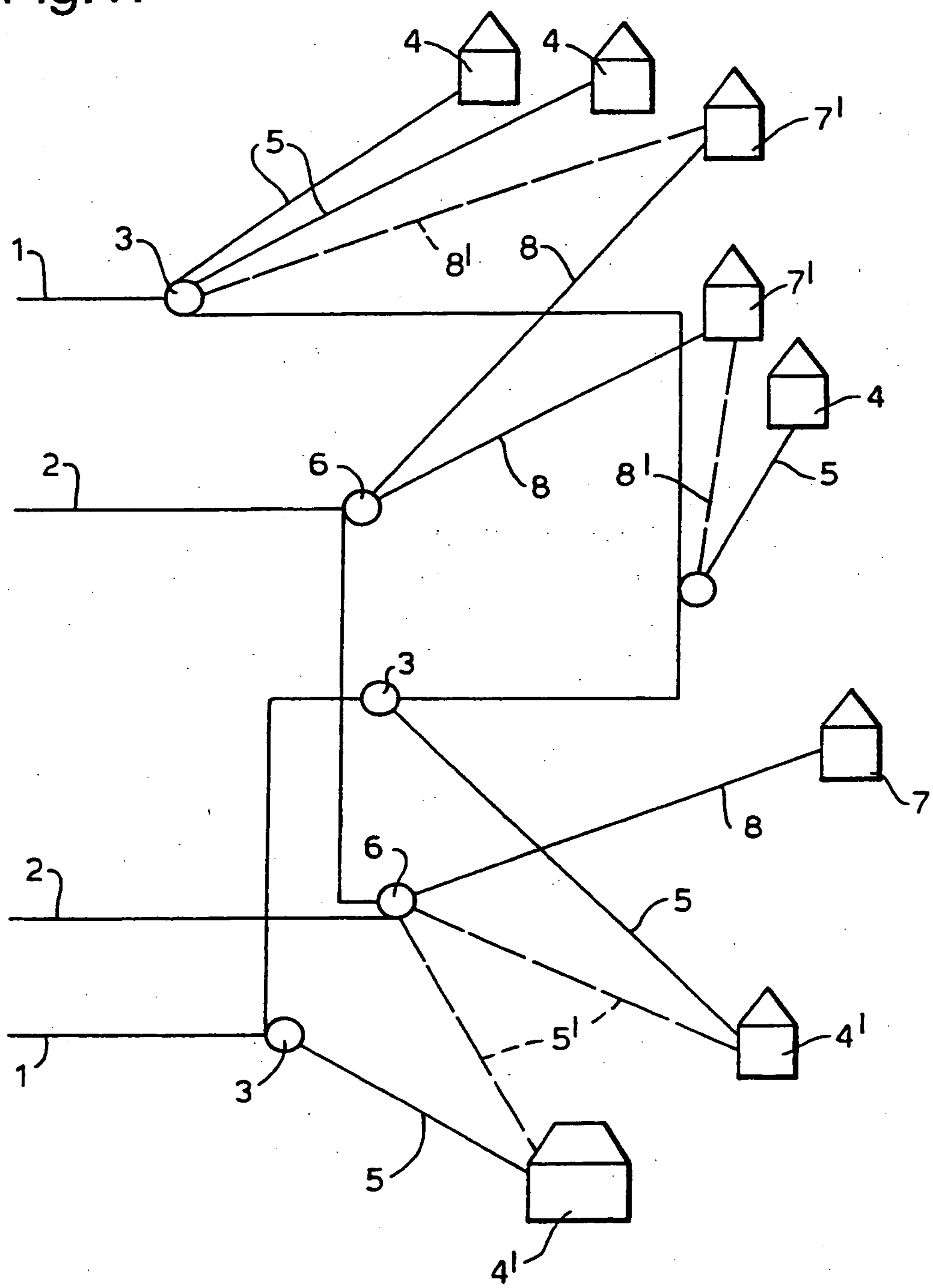
9. A network as claimed in claim 8 when appendant to claim 6, wherein each switch is associated with a respective PON, each PON having a first level of split constituted by the first level nodes, and a second level of split constituted by the second level nodes.

10. A network as claimed in claim 9, wherein each PON has a primary split which feeds the nodes of the first level.

11. A network as claimed in claim 10, wherein each primary split is provided on a fibre ring associated with the respective switch.

12. A network as claimed in claim 11, wherein each fibre ring is connected to its respective switch via a respective concentrator and a further fibre ring.

Fig.1.



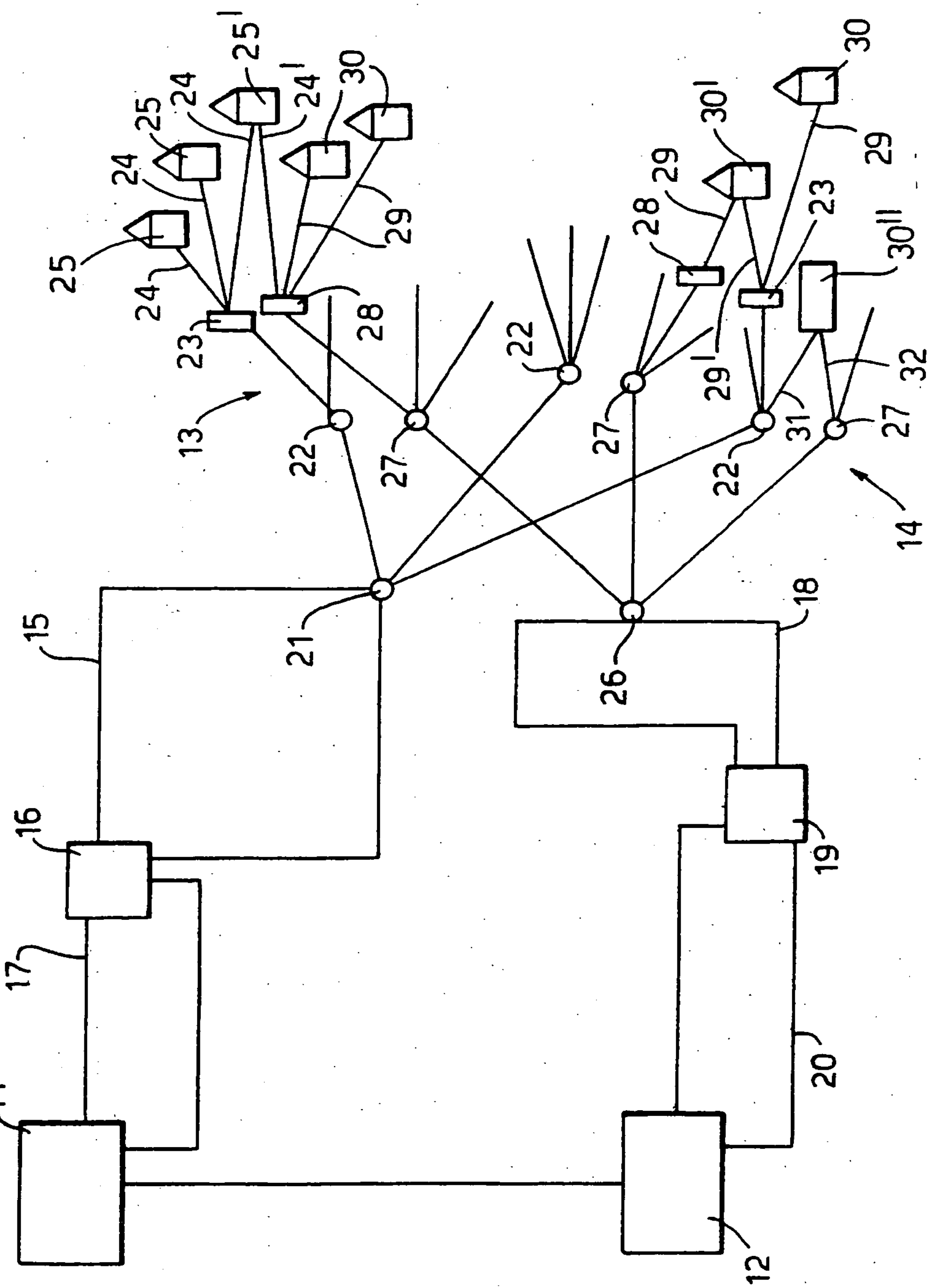

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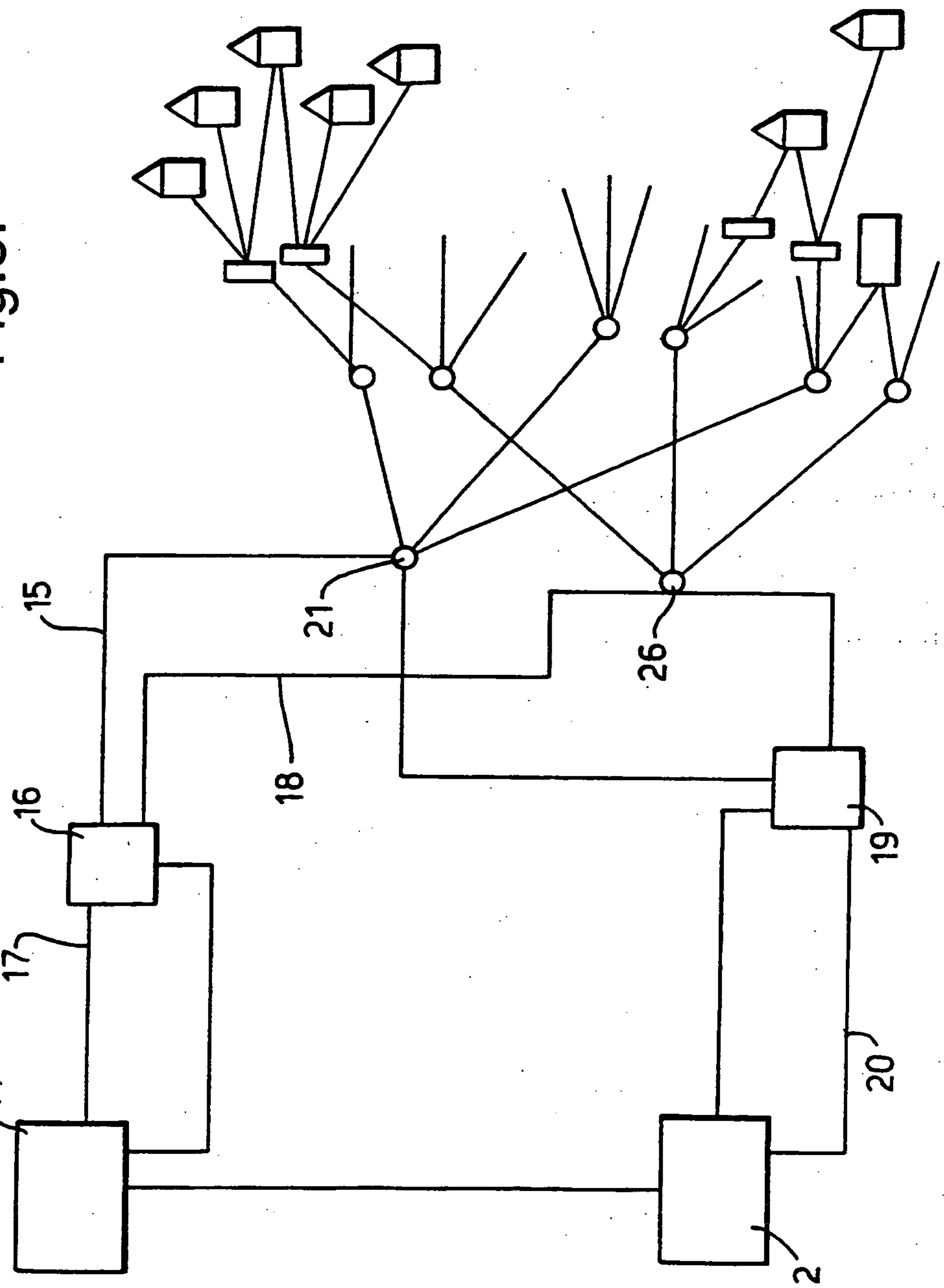
Fig.2.

Fig.3.



INTERNATIONAL SEARCH REPORT

Internat : Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04Q11/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	COMMUTATION ET TRANSMISSION, vol.14, no.4, 1992, PARIS FR pages 27 - 34, XP328635 J. ABIVEN ET AL. 'MOLENE : système de distribution d'accès à 2 Mbit/s sur réseau optique passif' see page 32, middle column, line 12 - page 33, left column; figures 1,5	1,4,5,8
Y		2,3,6, 9-12

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
14 September 1995	06.10.95

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Interna :l Application No
PCT/GB 95/01298

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